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(54) **Electromagnetic locks for doors**

(57) An electronically operable lock includes a first winding 10 which is used for transmitting pulses to a key circuit 12. The key circuit rectifies the pulses received to provide a d.c. power supply for transmitting a key code back to the lock via the first winding. The lock electronic circuit compares the received coded signals with at least one stored code and operates to release the lock if the comparison is correct. The first winding may also be used as the coil of an electromagnetic clutch.

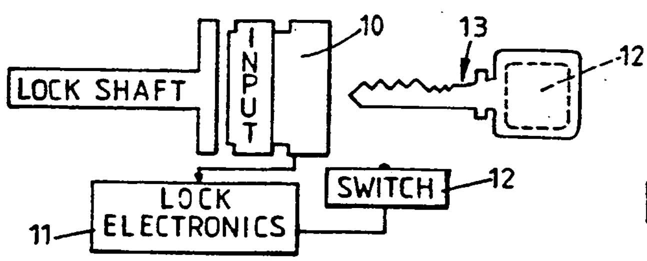

FIG.1.

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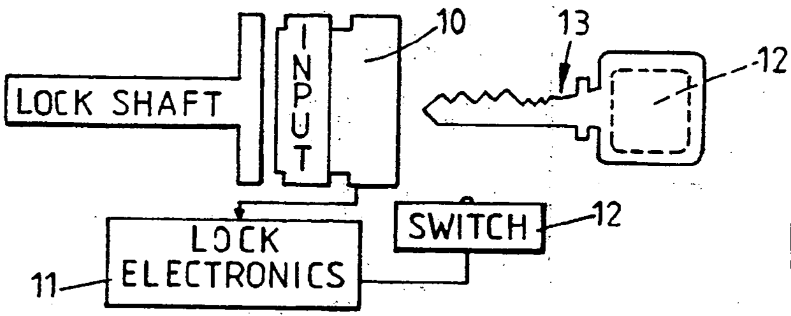

FIG.1.

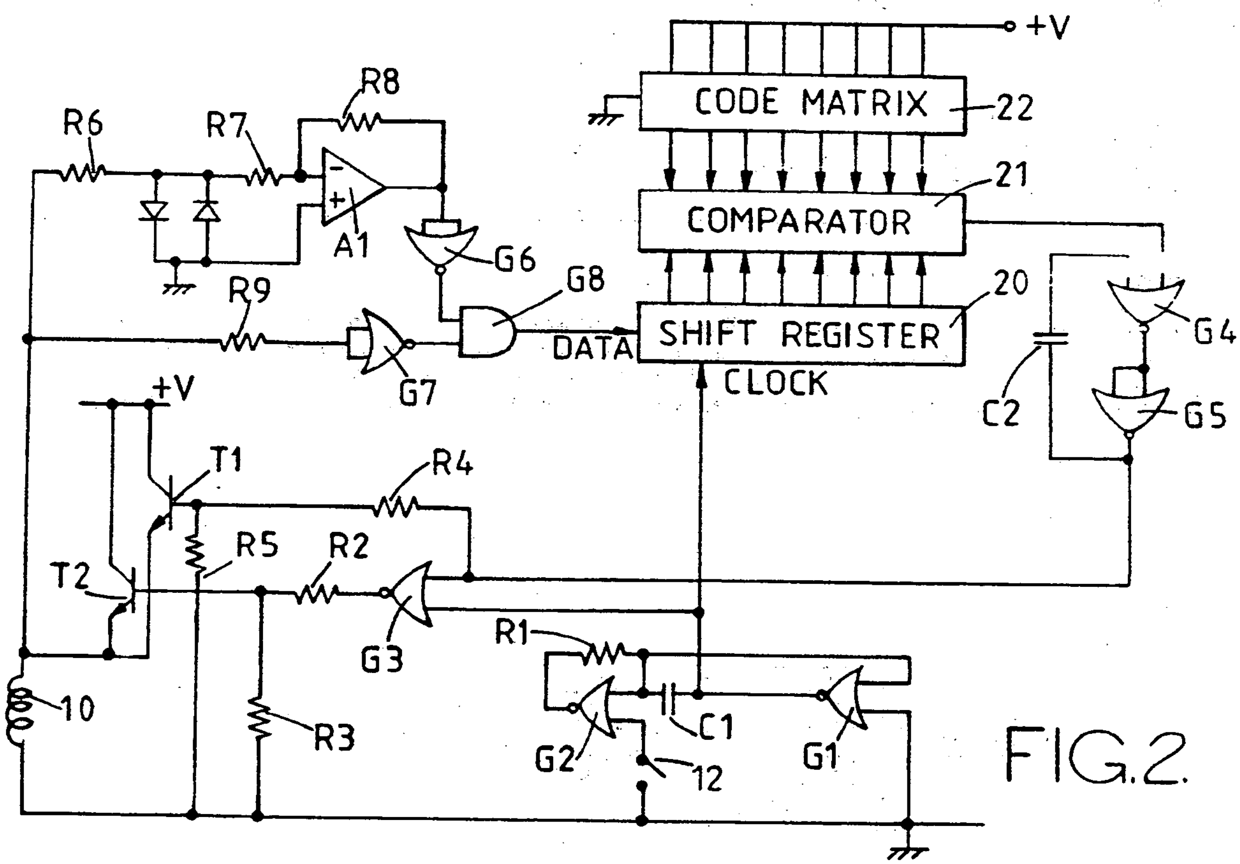

FIG.2.

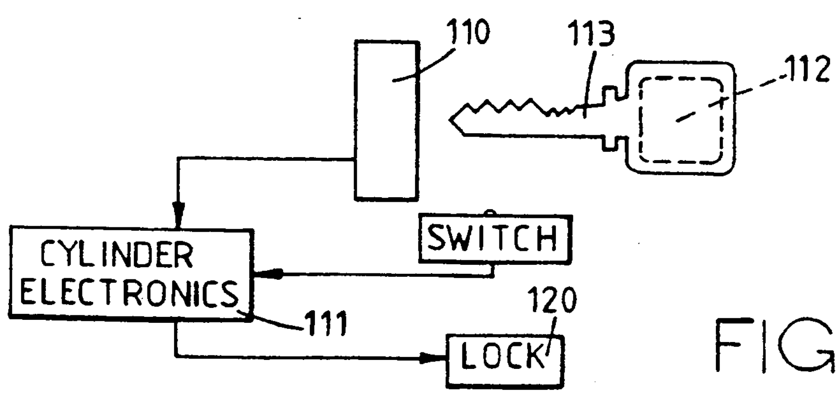

FIG.5.

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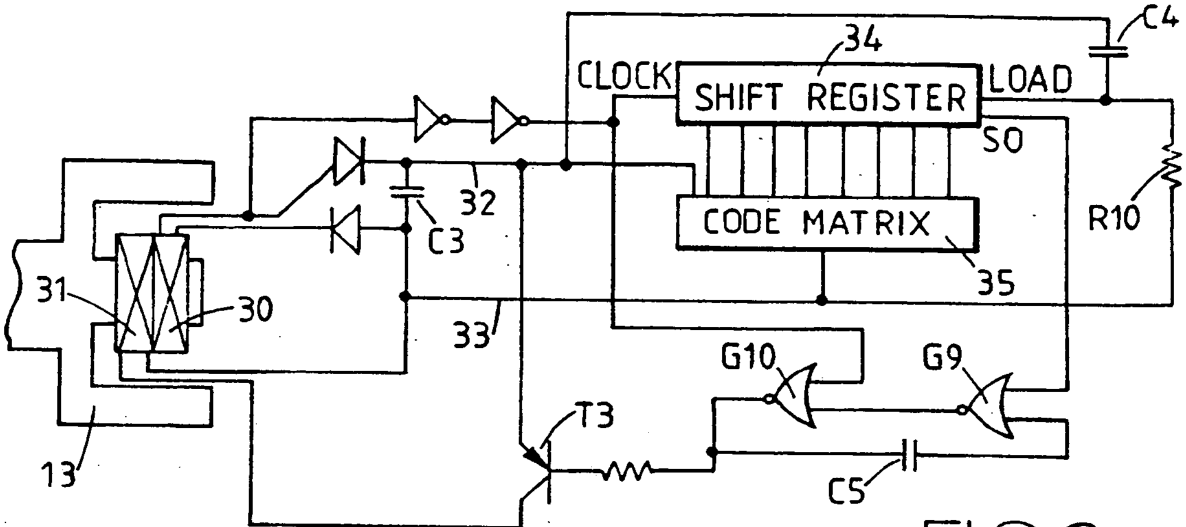

FIG.3.

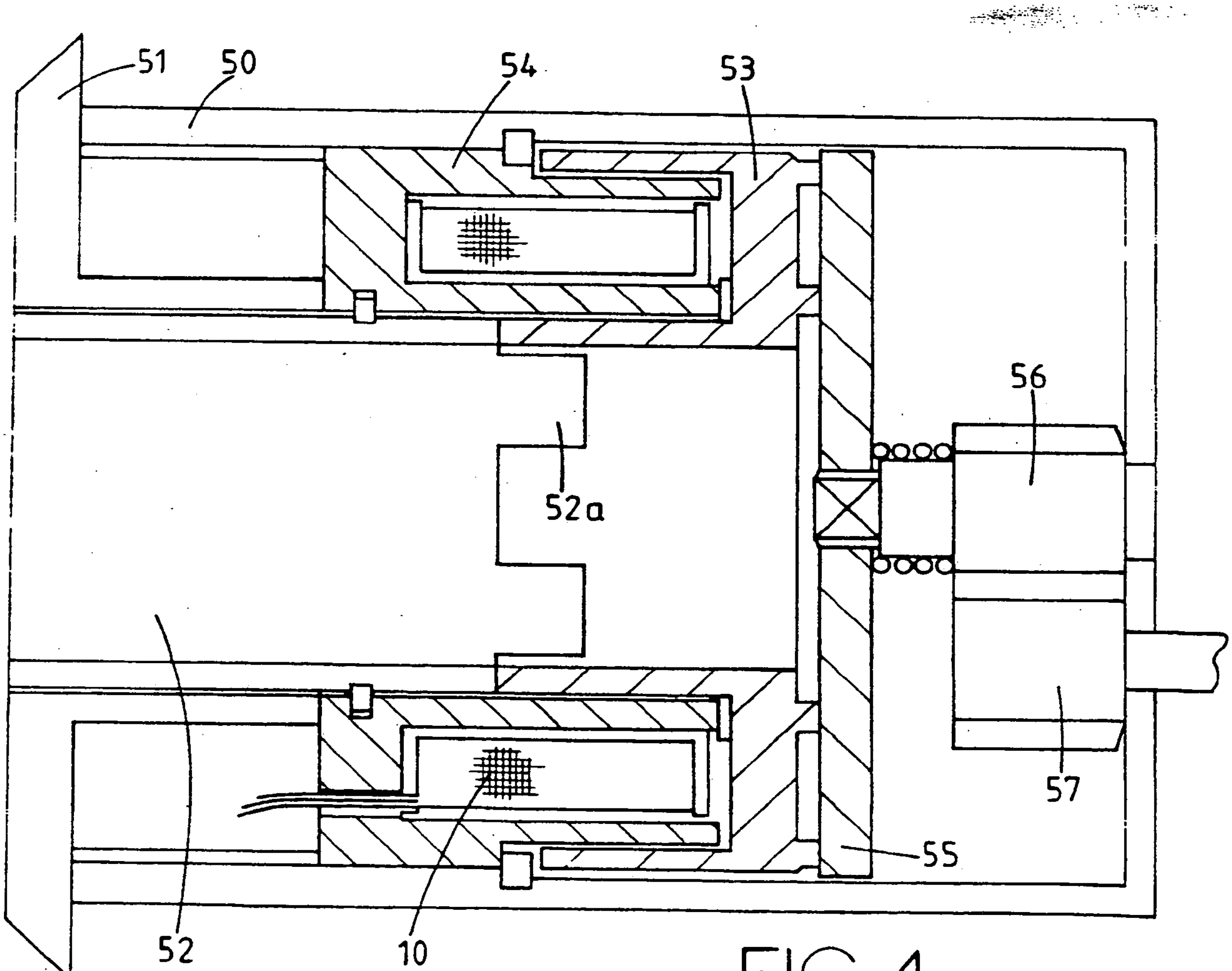

FIG.4.

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ELECTROMAGNETIC LOCKS FOR DOORS AND THE LIKE

This invention relates to electromagnetic locks for doors and the like.

Various proposals have already been put forward for locks in which data is transmitted from an "active" key to a receiver in the lock to enable the lock to be operated. Ultra-sonic, electromagnetic and optical (including infra-red transmission) have been proposed, but, in general, such systems have the drawback that the key requires a power source and hence must be bulky and require either recharging or replacement of the power source from time to time.

It is an object of the invention to provide a lock/key combination which retains the known advantages of an "active" key without requiring a power source in the key.

In accordance with the invention there is provided the combination of an electronically operable lock with an active key in which an electronic circuit forming a part of the lock includes a first winding which is a.c. energised by said circuit, the key including a second winding which, when the key is presented to the lock, is electromagnetically coupled to the first winding so that power can be transmitted from the lock electronic circuit to a key electronic circuit, said windings also being employed in the transmission of data signals from the key electronic circuit to the lock electronic circuit for operating the lock electronic circuit.

In the accompanying drawings:-

Figure 1 is a block diagram showing one example of the invention;

Figure 2 is a circuit diagram showing an electronic circuit forming part of the lock of the Figure 1 embodiment;

Figure 3 is a block diagram showing in more detail an electronic circuit forming part of the key of the Figure 1 embodiment;

Figure 4 is a cross-sectional view of the embodiment shown in Figure 1, and

Figure 5 is a block diagram of an alternative embodiment of the invention.

Referring firstly to Figures 1 to 4, the system shown includes a lock winding 10 which serves three functions. Firstly it enables energy to be transferred from an electronic circuit 11 forming part of the lock to an electronic circuit 12 in a key 13. Secondly, it allows signals to be transmitted from the key electronic circuit 12 to the lock electronic circuit 11, to enable the latter circuit to determine whether the key is one which is permitted to operate the lock. Thirdly it acts as a solenoid of an electromagnetic clutch to enable turning of the key to be transmitted to a lock drive shaft 14.

The lock electronic circuit shown in Figure 2 includes an oscillator comprising two NOR gates G_1 and G_2. The gate G_2 has one input connected to supply ground by a switch 22 operable by the key 13 when it is fully inserted into a receptacle provided for it in the lock. The switch 22 is arranged to be closed by the

key 13 when the latter is in its fully inserted position. The output of gate G_1 is connected to the other input of gate G_2 by a capacitor C_1 and a resistor R_1 connects the output of gate G_2 to the inputs of both gates G_1 and G_2. The output of the oscillator is a square wave taken from the output of gate G_1.

It will be appreciated that when the switch 22 is open the oscillator does not operate. The square wave output is provided only when the switch 22 is closed by full insertion of the key into its receptacle.

The output of the oscillator is connected to one input of a NOR gate G_3, the output of which is connected via a resistor R_2 to the base of an npn transistor T_1 which has its collector connected to the positive terminal of a power supply (either battery or mains powered) included in the lock. The base of transistor T_1 is connected by a resistor R_3 to ground. The emitter of transistor T_1 is connected to one end of the winding 10, the other end of which is grounded.

The other input terminal of gate G_3 is connected to the output of a pulse generator circuit comprising two NOR gates G_4 and G_5. Gate G_4 has one input connected by a feedback capacitor C_2 to the output of gate G_5, which has both of its inputs connected to the output of gate G_4. The value of the capacitor C_2 is chosen so that this pulse generator provides a signal which is high for about 4 seconds after a high pulse is applied to the other input of gate G_4. During this 4 second pulse gate G_3 is disabled.

The output of gate G_5 is also connected by a resistor R_4 to the base of a circuit comprising two diodes D_1, D_2 oppositely connected in parallel with one another.

One side of this circuit is connected by a resistor R_6 to said one end of the winding 10 and by a resistor R_7 to one input of an operational amplifier A_1. The other side of clipping circuit is grounded. The other input of the amplifier A_1 is also grounded and a feedback resistor R_8 is connected between the first-mentioned input and the output of amplifier A_1.

A NOR gate G_6 is connected to the output of amplifier A_1 to act as a logical inverter and another such gate G_7 has its inputs connected via a resistor R_9 to the said one pnp transistor T_2 which has its collector connected to the positive supply terminal. The emitter of transistor T_2 is connected to said one end of the winding 10 and another resistor R_5 connects its base to ground. Transistor T_1 supplies a square wave a.c. signal to the winding 10 from transmitting pulses to the key. Transistor T_2 supplies a 4-second pulse to the winding 10 to operate the clutch. Gate G_3 interrupts the square wave pulse train for the duration of the 4-second pulse.

For operation as receiver to receive signals transmitted back from the key, the lock circuit includes a diode clipping end of the winding 10. An AND gate G_8 has its inputs connected to the outputs of the gates G_6 and G_7.

Gate G_7 operates to inhibit gate G_8 whenever either of the transistors T_1 or T_2 is on. Amplifier A_1 amplifies low level signals picked up by the winding 10 to logic level. Hence gate G_8 provides an output only when the input to the amplifier A_1 remains high whilst neither transistor T_1 or T_2 is switched on. The signal from gate G_8 is used as a data signal which is taken as being characteristic of the key in the receptacle.

The data signal is clocked into a serial in, parallel out shift register 20, which is clocked by pulses from the oscillator G_1, G_2. The parallel output terminals are connected to one set of input terminals of a digital comparator circuit 21. The other set of input terminals of circuit 21 is connected to a code matrix which may simply be an array of links connecting these input terminals to either the positive supply terminal or ground.

The operation of the lock circuit is thus very simply as follows.

When a key is inserted in the lock receptacle, the oscillator G_1, G_2 is enabled and the square wave pulse train referred to above is applied to the winding 10. In the intervals between these pulses, the data signal at the output of gate G_8 is clocked into the shift register 20. If, after eight pulses, the digital code held by the shift register 20 matches the code set by the digit matrix 22, the comparator circuit 21 provides an output which fires the pulse generator G_4, G_5 so as to energise the winding 10 continuously for 4 seconds, during which time turning of the key will be transmitted by the clutch to the door lock or latch mechanism, allowing the door to be opened. If the correct digital code is not fed into the shift register 20 the circuit will continue to run, repeatedly clocking data into the shift register, but no clutch energising pulse will be produced.

Turning now to Figure 3, the electronic circuit included within the key 13 comprises two windings 30, 31 mounted on a magnetic core formed by the body of the key, which is formed of a ferrous metal. The winding 30 is a receiving winding and has its two ends connected

by respective diodes D_3, D_4 to two power supply lines 32, 33 between which a smoothing capacitor C_3 is connected. When the key is inserted into the lock receptacle and the oscillator in the lock starts to run, the capacitor C_3 is charged up to provide power for the circuit in the key.

The key circuit also includes a parallel in, serial out shift register 34 and a code matrix 35 which determines the digital code to be loaded into the register 34 at power up. To this end the LOAD terminal of the shift register is connected by a capacitor C_4 to the line 32 and by a resistor R_{10} to the rail 33. The code thus loaded is clocked out of the SERIAL OUT (SO) terminal of the register 34 by clock pulses derived (by a suitable drive circuit) from the winding 30.

The winding 31 is connected in series with the collector-emitter path of a transistor T_3, across the supply lines 32, 33. Transistor T_3 is controlled by a pulse generator circuit comprising two NOR gates G_9, G_{10}, with a feedback capacitor C_5, clocked by the clock pulses referred to above, and driven by the serial output of the shift register 34. The capacitor C_5 has a value chosen to ensure that the duration of the pulses produced by this pulse generator is less than half the period of the clock pulses. The pulses are produced in the interval between the clock pulses.

It will thus be appreciated that the oscillator G_1, G_2 of the lock electronics provides the main timing control for the system. On invitation of operation of this oscillator, the key electronics is powered up, the register 32 is loaded and its contents are clocked out and transmitted by coil 31 during the intervals between the drive pulses applied to the coil 10.

If the code set by the code matrix 35 in the key matches that set by the code matrix 22 in the lock, the clutch will be energised to allow opening of the door. If the lock fails to operate the user can try again by withdrawing the key for a time sufficient for the various capacitors in the system to discharge and then re-inserting it.

The example described above is a very simple one allowing only one code to operate the lock. A more sophisticated system can be employed, if a micro-processor is installed in the lock and is programmed with a plurality of different acceptable codes. Such a system may include means for remembering the number of accesses made by each key code and the times of such accesses.

If desired arrangements may be made for permitting two-way communication between the lock electronics and the key electronics. For example the key may include non-volatile memory which can receive data transmitted from the lock electronics. Such data may include changed access codes or data concerning the locks on which the key has been used (including locks which the key will not actuate).

Turning now to Figure 4, the construction of the lock is shown in more detail. The lock has a body 50 and a front member 51 formed of a non-ferrous metal. A rotatable cylinder 52 (in which the keyway or key receptacle is formed) is also made of a non-ferrous metal. This cylinder 52 is rotationally coupled (by castellations 52a thereon to the input member 53 of the electromagnetic clutch, which member 53 is formed of a ferromagnetic material. The winding 10 is contained in a yoke ring 54 also of ferromagnetic material. As shown

this yoke ring 54 has one axial end projecting into an annular recess in the input member. The clutch has an output member in the form of a disc 55 of ferromagnetic material which is attracted to the input member 53 when the winding 10 is energised so that rotation of the cylinder 52 is transmitted frictionally to the disc 55. The disc is mounted on a gear 56 which is meshed with a gear 57 on an output shaft coupled to a latch device (not shown).

Turning now to Figure 5, the coil 110 therein acts only to transmit power to the key electronics and receive modulated signals from the key. A completely separate electromagnetic lock mechanism 120 is driven directly by the lock electronics.

CLAIMS

1. The combination of an electronically operable lock with an active key in which an electronic circuit forming a part of the lock includes a first winding which is a.c. energised by said circuit, the key including a second winding which, when the key is presented to the lock, is electromagnetically coupled to the first winding so that power can be transmitted from the lock electronic circuit to a key electronic circuit, said windings also being employed in the transmission of data signals from the key electronic circuit to the lock electronic circuit for operating the lock electronic circuit.

2. The combination claimed in claim 1 in which said first winding also forms part of a clutch for permitting mechanical actuation of the lock by a lock operating element.

3. The combination as claimed in claim 1 in which the lock electronic circuit includes an oscillator for applying pulses to said first winding, said key electronic circuit including transmission means for transmitting a key coded store in the key to the lock in intervals between said pulses.

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